Washington State
Department of Transportation

A Report requested by the Governor
of the State of Washington

Unstable Slopes on I-90 Snoqualmie Pass

Re-assessment and Recommendations

January 2006

Douglas B. MacDonald
Secretary of Transportation

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The principal technical authors of this report are Steve Lowell, L.G., L.E.G., Chief Engineering Geologist, and Tom Badger, L.E.G. and P.E., Assistant Chief Engineer in the WSDOT Geotechnical Division, P.O. Box 47365, 1655 S. 2nd Avenue, Tumwater, WA 98512

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Executive Summary

The purpose of this report

Due to concerns arising from two recent rock slope failures (September and November 2005) along the westbound lanes of Interstate 90 on either side of Snoqualmie Pass, Governor Christine Gregoire directed WSDOT to perform an evaluation of slope hazards along the I-90 corridor over the Pass. This report is the result of that evaluation and makes recommendations on I-90 slope management issues. These include matters that should be considered by the Legislature and the Governor.

Unstable slopes presenting hazards to the state highway system

WSDOT's Unstable Slope Management System began in 1995 to collect information about and to mitigate unstable slopes presenting hazards to the state highway system. The system supports an ongoing Unstable Slopes Preservation Sub-program (P3) funded by the Legislature for projects over a course of years to correct conditions and mitigate risks presented by such hazards.

The system has led to the identification of approximately 2700 unstable slopes presenting hazards to state highways. The slope hazards include potential rock falls, landslides and debris flows. Forty of these sites, according to the most recent assessment, are located on the I-90 corridor over Snoqualmie Pass. Since 1995 about 100 sites around the states have been mitigated, including nine on Snoqualmie Pass, at an aggregate cost of approximately $130 million.

Setting of priorities for new mitigation projects takes account of a hazard and risk rating system (described in more detail in Appendix A). Under the rating process used in the system, about 10% of the 2700 inventoried sites are rated at 350 or above. Only projects at this hazard rating that affect a state highway along interstate facilities, principal arterials, and highways with an average daily traffic volume of 5000 vehicles or higher are now being considered for funding in the Unstable Slopes Preservation Sub-program (P3).

Details of the WSDOT program are reported in Section 2 of this report (pages 9 to 17). WSDOT also asked Golder Associates, a nationally-recognized engineering consulting firm with specialized expertise in geotechnical engineering and risk management, to provide an independent overview of the program for inclusion in this report. It can be found in Appendix B.

I-90 Snoqualmie Pass corridor assessment

Geotechnical experts on WSDOT staff conducted this reassessment of the Snoqualmie Pass I-90 corridor.[1] They examined the entire data record already contained in the Unstable Slope Management System inventory. Between Milepost 36 and 68, they also visually inspected each site on the corridor. They also consulted with WSDOT highway maintenance crews assigned to the I-90 corridor to collect information on frequency of rockfall or landslide events, an important clue to the condition of rock slopes and landslide areas. Their findings are included in Section 2 of this report (pages 18 to 57).

Rockfall and landslide risk experience on Washington's state highways.

Judgment about the mitigation of slope hazards – the right priority locations for the work and the right scale of effort when funds also must be available for other purposes within WSDOT – requires the practical exercise of risk management. The level of funding provided by the legislature for the Unstable Slopes Preservation Sub-program (P3) also reflects explicit or implicit risk-based decision-making about the tolerability of the slope hazards presented to those who travel on and depend upon the highways.

[1] *The principal technical authors of this report are Steve Lowell, L.G., L.E.G., Chief Engineering Geologist, and Tom Badger, L.E.G. and P.E., Assistant Chief Engineer in the WSDOT Geotechnical Division, P.O. Box 47365, 1655 S. 2nd Avenue, Tumwater, WA 98512*

Executive Summary

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In order to include relevant background in this report, WSDOT examined historical information of accident experience on the state highways since 1970 and found that the risk of fatality or injury to highway users from rockfall or other slope hazards was very small in comparison to other kinds of highway travel risks. During that period, WSDOT believes that ten deaths (out of a total for the period of over 13,000) on the state highway system can be attributed to the effect of a slope hazard upon the highway. This information is included in Section 4 of this report (pages 89 to 91).

The economic cost of highway closures or restrictions from slope hazards certainly can be appreciable, as the recent restrictions on I-90 have amply demonstrated. However, they are difficult to calculate. WSDOT crews managed to keep I-90 operating - although with restrictions that burdened some travel - for most of the period during which corrective work was performed as a consequence of the two recent slides. WSDOT has not calculated an economic cost of the incidents reflecting those circumstances, but a record of highway closures since 1985 to 2005, has been prepared and is included in Section 5 of this report (pages 93 and 94).

Slope hazards on highways other than Interstate 90

New initiatives for slope hazard mitigation on Interstate 90 must be considered not only in light of conditions encountered on Snoqualmie Pass. Account must also be taken of hazards presented to other state and interstate highways in the state highway system. Interstates like I-90 (also I-5) carry very large volumes of daily traffic and have especially significant roles in the state's commerce. However, many other well-traveled routes are exposed to high hazard high risk slope conditions. A tabulation of slope hazards for several other corridors was prepared for this report in order to give context to discussion of additional or accelerated mitigation work on I-90, whether under the Unstable Slopes Preservation Sub-program (P3) or another funding source. This material is included in Section 3 of this report (pages 59 to 88).

Executive Summary

(Continued)

Recommendations and conclusions

This report makes five recommendations. The recommendations are set forth in full at the conclusion of Section 2 (pages 14 to 17), the detailed assessment of the I-90 corridor on Snoqualmie Pass.

All the recommendations in this report must be taken in the context that travel on highways in Washington State, particularly where geological conditions and gravity conspire to produce inevitably uncertain outcomes for slope hazards, will be attended by risk.

Geotechnical review of particular slope conditions and slope hazards in general can only offer uncertain insights into the character and likely behavior of geologic conditions that are driven by the forces of nature or even by the human hand in making past alterations of natural conditions by road-building. Events beyond anyone's ability to predict or even perhaps to protect against – including rockfall events at the very locations examined in this report – can occur at any time in many places and cannot be entirely warranted against by WSDOT's analytic or engineering work efforts. The recommendations, therefore, are WSDOT's best attempt consistent with established engineering practice at appropriate, if uncertain, risk management and cannot promise freedom from risk or indemnification against risk.

*The **first recommendation** is that many of the slope hazards identified on the I-90 corridor and not yet mitigated should continue to be treated along with other risks on other corridors in the overall statewide Unstable Slopes Preservation Sub-program (P3). As funds permit and as prioritization is generally carried out in the program, these slopes will be expected to be mitigated at a future time. The risk of awaiting the ordinary course of the program is thought to be necessarily and appropriately tolerated in light of other spending needs inside and outside the Unstable Slope Management Program (P3).*

*The **second, third and fourth recommendations** are exceptions to the first recommendation and suggest that special attention should be given to several specific sites. The circumstances are different for each of the three recommendations and they should be consulted where they have been stated in detail on pages 15 and 16. The **fourth recommendation** includes a plan (with a funding proposal) for mitigating as promptly as possible three closely adjoining hazard areas near Milepost 66. (see pages 53 to 55).*

*The **fifth recommendation** is that in general (not solely or even specifically on the I-90 Snoqualmie Pass corridor), WSDOT's Unstable Slopes Preservation Sub-program (P3) should incorporate a risk reduction strategy of selective rock scaling to complement its projects of permanent slope stabilization. This follows emerging practice in other agencies involved in progressive slope hazard management programs such as the British Columbia Ministry of Transport and the Canadian Pacific Railway. The appropriate extent of this work within the overall program and the determination of its most useful locations will, like other aspects of the program, fall to the professional judgment of WSDOT's geotechnical specialists and can be accomplished without additional legislative or gubernatorial action. However, to avoid taking away limited P3 funds and impacting stabilization projects serving long-term permanent objectives, additional funds will be needed (additional funds estimated at $1 million per biennium) to proceed with this risk reduction strategy.*

*The **sixth recommendation** is for funding of emergency repairs not expected to be covered by federal Emergency Relief funds that have arisen in the unusually expensive experience of FY 2006. This includes the two slide areas on I-90 that have given rise to this report as well as other slide areas around the*

state principally associated with the winter season's heavy rains. The recommendation is for reinstitution of an emergency bond authorization (as was used for similar purposes in the 1990s) and a matching appropriation of the bonds proceeds to fund this work. The bond authorization is recommended at the level of $50 million, of which approximately $7 million will be required for funding the emergency repairs not otherwise funded in FY 06 to this date.

This report has been prepared by WSDOT within short months of the tragic loss of three lives on I-90 on Snoqualmie Pass when Janet J. Ichikawa of Lynnwood, Heather E. Rider of Castle Rock and Janel A. Lindsey of Bothell lost their lives as their vehicle was crushed by falling rock on September 11, 2005. Every traffic fatality in Washington State is a tragedy for the victims and their friends and family members, and every traffic fatality also weighs on our public employees charged with the highways' construction, operation and maintenance. This is even, or perhaps especially, true when nature's hand itself intercedes on the highways:

though the earth be removed,

and though the mountains be carried into the midst of the sea.

Psalm 46

We hope that the serious purpose with which this report has been prepared and considered by WSDOT is due dedication to the memory of these women and the condolences we wish their families and loved ones.

Douglas B. MacDonald

Secretary of Transportation

Introduction

At the request of the Governor of the State of Washington, Christine Gregoire, the Washington State Department of Transportation (WSDOT) has completed an assessment of the known unstable slopes along Interstate 90 between Milepost 36 and Milepost 68.

The report has been divided into six sections to provide relevant information on WSDOT's Unstable Slope Management Program, a detailed reassessment of unstable slopes located in the vicinity of Snoqualmie Pass, unstable slope information on other problematic highway corridors, data on major highway closures, an assessment of accidents related to unstable slopes, and a discussion of the selected slope hazard issues of avalanches on the I-90 corridor. These are two appendices. One is an independent assessment of WSDOT's Unstable Slope Management System by Golder Associates, the other provides detailed background on the hazard rating system used at WSDOT in the Unstable Slope Management System.